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Dear Sir,

SUBMISSION OF PRIORITY DOCUMENTS

Serial No: 10/077,846

Confirmation No: 3208

Art Unit: 1724

Applicant: JOWETT, E. Craig

Title: In-Pipe Wastewater Treatment System

Our File Ref: 268-57US

We now submit the certified copies of the priority documents in respect of the above patent application.

Submitted by,

A handwritten signature in dark ink, appearing to be "A. Asquith".

Anthony Asquith  
(Regn 32373)  
Agent for the Applicant

Enclo:

Certified Copies

GB-0125266.7

GB-0104693.7

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**TC 1700**

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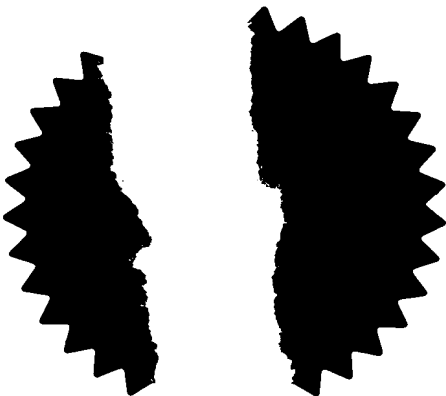
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Signed

*Andrew Gurney*

Dated

28 APR 2002

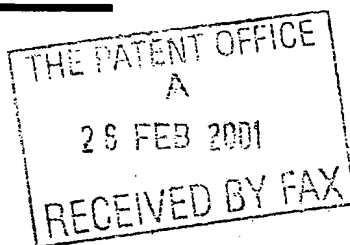
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1. Your reference

268-559B.

099970 7277\*970\*99 7974\* 33  
27Feb01 2604083-1 1002986  
P01/7700 0.00-0104693.7

2. Patent application number

(The Patent Office will fill in this part)

23 FEB 2001

0104693.7

3. Full name, address and postcode of the or of each applicant (underline all surnames)

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08090680001

Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation

4. Title of the invention

WASTEWATER TREATMENT SYSTEM

5. Name of your agent (if you have one)

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

Anthony Asquith

328 LEEDS RD

SCHOLES

LEEDS

LS15 4DD

Patents ADP number (if you know it)

026570916003

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country

Priority application number  
(if you know it)

Date of filing  
(day / month / year)

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing  
(day / month / year)

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

- a) any applicant named in part 3 is not an inventor, or
- b) there is an inventor who is not named as an applicant, or
- c) any named applicant is a corporate body.

See note (d))

# Patents Form 1/77


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Continuation sheets of this form

Description 

Claim(s)

Abstract

Drawing(s) 

10. If you are also filing any of the following, state how many against each item.

Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (*Patents Form 7/77*)

Request for preliminary examination and search (*Patents Form 9/77*)

Request for substantive examination (*Patents Form 10/77*)

Any other documents  
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11. I/We request the grant of a patent on the basis of this application.

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## WASTEWATER TREATMENT SYSTEM

This invention relates to typically aerobic, microbial treatment of domestic and commercial sewage and other wastewaters, and to the renovation of polluted water in general.

One common arrangement for treating wastewater has the following elements or stations: (a) an anaerobic digester station; (b) an aeration station; and (c) an infiltration station.

The anaerobic digester station may comprise a septic tank. Here, solid materials in the wastewater can settle out, and reductive breakdown reactions can take place, which break down much of the organic content of the wastewater, both solid and dissolved. Dissolved ammonium in the water is largely not affected by passage through the septic tank. Water emerging from a well-engineered septic tank has only a small undissolved (i.e solid) organic content. One of the functions of the aeration station is to remove the remaining dissolved organic content (as well as to convert the ammonium content to nitrate).

In the aeration station, the oxidation reactions can take place. In passing through a well-engineered aeration station, the carbonaceous-BOD content is oxidised to inconsequential liquids and gases.

The infiltration station mainly serves the mechanical purpose of infiltrating the water into the ground, rather than promoting treatment reactions. An infiltration station is well engineered if water infiltrates into the ground without disruption to the ground and without clogging, etc, over a long service life.

In traditional septic-tank wastewater treatment systems, the aeration station and the infiltration station have been combined in a single structure, comprising a tile-bed soakaway. The present invention relates to treatment systems in which the aeration station is a separate structure from the infiltration station, and follows generally from the technologies disclosed in the following U.S.A. patents: 5,707,513 5,762,784 5,980,739 5,997,747 6,063,268 6,156,094.

The invention is aimed at providing a new form of aeration station, which is very efficient from the standpoint of utilisation of premium space, and yet which vigorously promotes the carbonaceous-BOD oxidation reactions. It is an aim of the invention that the new aeration station should require no more input of ingredients or energy, and no more attention or service, than is

required in traditional conventional septic tank systems. (It should be understood that conventional septic treatment systems sometimes include electric pumps and other active components, and septic systems commonly need to be serviced every year or two.)

In the invention, the aeration station has a long, narrow configuration. So much so, that it becomes convenient to fit the aeration station into a pipe. In a preferred arrangement, which will be described, the aeration station is located in a pipe that transfers water from the effluent port of the septic tank to the ground-infiltration station. Unlike conventional tile-beds, the aeration stations as described herein are generally not suitable for serving double duty as ground-infiltration stations.

Hitherto, it has not been practical to configure an aeration station to fit in a pipe. It has not previously been proposed how the constraint that the water flows at a large velocity (though not all the time) might be overcome. Aerobic treatment reactions require microbes, and require vigorous colonies of microbes, and it has been considered impractical to house the colonies of microbes actually in the pipe. It has been considered that a pipe is for moving water, not for treating water.

#### DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

By way of further explanation of the invention, exemplary embodiments of the invention will now be described with reference to the accompanying drawings, in which:

Fig 1 is a diagrammatic cross-sectioned side view of a system for treating wastewater that embodies the invention.

Fig 2 is a pictorial view of a body of foam material, which is a component of the system of Fig 1.

Fig 3 is a close-up of a portion of Fig 1.

Fig 4 is a plan view of the treatment system of Fig 1.

Fig 5a is a diagrammatic cross-sectioned view of a pipe containing a body of treatment material.

Fig 5b is the same view as Fig 5a, but shows a different condition.

Figs 6a,6b correspond to Figs 5a,5b, but show a different treatment material.

Fig 7 is an end view of another system for treating wastewater that embodies the invention.

Fig 8 is a cross-sectioned side-view of the system of Fig 7.

Fig 9 is an end view, like Fig 7 of another system that embodies the invention.

Fig 10 is a cross-sectioned side-view of the system of Fig 9.

Fig 11 is a pictorial view of another system that embodies the invention.

The systems shown in the accompanying drawings and described below are examples which embody the invention. It should be noted that the scope of the invention is defined by the accompanying claims, and not necessarily by specific features of exemplary embodiments.

In Fig 1, the pipe 20 has a length of about fifteen metres, and a diameter (internally) of about twenty-five centimetres. The pipe 20 is made of a plastic material that is inert as far as wastewater and the pollutants commonly found in wastewater are concerned.

Inside the pipe 20 is a body 23 of plastic foam material. Again, the foam is of a plastic material that is inert as far as wastewater and the pollutants found in wastewater are concerned. (Types of treatment material other than foam may be considered for use in the invention, as will be described later.)

The body 23 of foam is configured as shown in Fig 2, and is dimensioned so as to fill the pipe 20, except that an air passage 24 is created between the top of the foam and the roof 25 of the pipe 20. The body 23 of foam is tight against the floor 26 of the pipe. The air-passage 24 is open to the atmosphere. The air-passage 24 is of large enough cross-section to ensure that air can pass easily along and through the whole length of the pipe 20. In the 25-cm diameter pipe, as shown, the air-passage 24 should have a cross-sectional area of about forty square cm.

The air-passage 24 also serves another purpose. If there were to be a sudden excess influx of wastewater, the overflow of water can be received into the air-passage, and can be directed further down the pipe, until it can infiltrate down into the foam. Of course, the treatment system must be adequate for the task for which it is designed, and the system would be inadequate if an overflow of incoming water could reach, and be discharged from, the far end of the pipe without soaking down into the foam.

It will be understood also that if the foam material near the inlet should become plugged (e.g with slime or other solid treatment products), whereby water is inhibited from soaking into the foam material, again the incoming water can be received in the air-passage, and can thereby be directed further down the pipe.

The air-passage 24 must be large enough to perform these functions. If the excess overflow water flowing down the air-passage is to have the opportunity to soak down properly into the foam, the surface area of foam presented to the water must be adequate; that is to say, if the air-passage were too small, the overflow water might be conducted right through the air-passage,

and be discharged, untreated, from the far end of the pipe. For this reason, the designer should see that the cross-sectional area of the air-passage 24 is at least ten square cm. Also, if the cross-sectional area of the air-passage were smaller than ten sq cm, air access to the foam might be inadequate. The main purpose of the pipe 20 is to contain treatment material, rather than to contain air passage; so, given that the 25-cm pipe 20 has a total cross-sectional area of about 491 sq cm, the air-passage 24 should not be more than about 100 sq cm.

The foam is of the interconnected open-cell type, whereby water can pass through the cells of the foam with a measurable velocity. The cells are small enough to provide a substantial capillary effect. The capillary effect should be strong enough that, after the pipe 20 has been filled with water, such that the body 23 of foam material is saturated, and then after the water has drained freely out of the pipe, some water is retained in the body of foam material. The foam material should be such that after a period of, say, one hour after dosing has ended, water is retained to a depth 27 (Fig 1) of between five cm and fifteen cm. If more water were to drain away than this, the water would not be retained in the pipe for a long enough residence time. If more water than this were retained, that would mean the foam was too tight, whereby incoming water might tend to flow straight through the pipe, i.e through the air-passage 24, rather than to infiltrate down into the body 23 of foam material.

To have the right degree of capillarity for use in the invention, the foam preferably should have a porosity of between about ninety percent and ninety-six percent.

After the system has been in use for long enough to reach steady operating conditions, the free-standing depth 27 of water will be present in the pipe at all times.

In most domestic wastewater systems, water enters the pipe not as a steady flow but as periodic doses. Of course, systems vary as to volume of water per dose, and as to the frequency of dosing. A typical system might have an average dose size in the ten to twenty litre range, at a dose rate between ten and a hundred times a day.

As a water dose arrives, so the incoming water fills up the left end of the pipe. Now, there is (or may be) more water at the left end of the pipe than can be supported by the capillary action of the foam at that location. Depending on other conditions of operation, water already present at the left end of the pipe is displaced further along the pipe, i.e to the right. The effect is progressive, whereby when twenty litres of water enters at the left end, a corresponding twenty litres of water is discharged (after a period of time) from the right end. But the water that is

discharged from the right end is water that has been resident inside the pipe for a considerable time, having been displaced progressively, in a bucket-brigade mode of progression, rightwards along the pipe as more water is dosed in from the left.

It will be understood that, usually, as a new dose of water is added at the left end, a corresponding equal volume of water will not be immediately discharged at the right end. The discharge might be immediate if the pipe had not been left to drain at all since the previous dosing, and the foam material in the pipe would be already saturated to full capacity. But usually, the foam material in the pipe will have drained enough, between dosings, that it takes a considerable time lag time for a dose applied at the left end to produce a corresponding discharge at the right end. Indeed, the designer should seek to so arrange the system that, in spite of the dosings of water at the left end being periodic, there is a more or less steady trickle or discharge flow of water (of the same aggregate flow rate) at the right end. The standing water level 27 represents the level at which the water is retained, by capillary action, over substantially long periods; dosing causes the water level to rise quite quickly, at the left end, above the level indicated by numeral 27, but then the water level drops back to the level 27 much more gradually. Consequently, water trickles out gradually from the right end.

The designer should see to it that the system is sized, in relation to the dosing rate, such that the water has a residence time, within the pipe, of preferably about twelve hours. Of course, the residence time depends not only on the sizing and arrangement of the treatment material, but also on the wastewater-producing habits of the owners/users of the system. But the designer should recognise that a system in which wastewater might pass right through the aeration station in less than about two hours would not be expected to treat the water adequately.

The water residing in the pipe is within a few centimetres of a supply of oxygen, i.e the air in the air-passage 24. Under these conditions, colonies of aerobic microbes can form on the matrix of the foam material, and be extremely viable. The water level is static most of the time, and the water is slowly moving through the pipe, whereby the microbes have ample opportunity to extract the needed nutrients from the water, but the water is continually being replaced, so the microbes receive fresh supplies of nutrients.

If the designer can arrange for the stabilised capillary-supported depth 27 of the water to be more than about five cm, the aerobic reactions can be so thorough that a lower portion of the depth of water can be depleted of oxygen. In that case, anaerobic reactions can take place; these can be beneficial in that, if the conditions were purely aerobic, slime and solids might tend to build up in

the foam.

The block 28 of foam as illustrated in Fig 2 typically is 1 1/2 metres long. Several such blocks 28 make up the whole length of the body 23 of foam. As mentioned, the pipe 20 is fifteen metres long, and, in this particular case, the pipe contains ten blocks. As will be understood from Fig 3, sometimes the blocks 28 of foam will abut tightly, with no gaps, but it does not matter if gaps do appear between the blocks.

The pipe 20 may be in one long length, or may be of short lengths joined together. The designer preferably should arrange the system so that the foam material can be removed and replaced, for future servicing, which is generally more convenient if the pipe is straight, and in short lengths.

The blocks should be assembled into the pipe such that no passageway or conduit can open up, being a passageway that would allow the water to by-pass the foam, because that might allow the water to flow along the pipe without encountering the microbe colonies. It is important that the water does not just quickly pass through the habitation of a few microbes, but that the water should encounter metre after metre of vigorous colonies of microbes.

Of course, the blocks 28 must be the right way up: if any block were orientated such that the air-passage 24 was near the floor 26 of the pipe, water would simply flow through the air-passage, without treatment. While it is not essential that the air-passages of all the blocks be exactly at the top of the roof 25, it is important that the blocks should be orientated relative to each other such that the air-passages of the respective blocks match up, so that air can pass along the aggregate length of the pipe.

In some cases, it may be adequate for the air-passage 24 to be open at just one end of the pipe 20, but preferably the air-passage is open at both ends, in order to encourage air to move freely along the air-passage. Holes may be punched in the roof 25 of the pipe, to improve air circulation, if desired (provided water cannot escape through those holes, under all conditions of dosing rates and flow volumes).

Upon emerging from the exit-end 29 of the pipe, the treated water remains to be disposed of. It may be appropriate to empty the water straight into a stream or lake. Or, it may be appropriate to collect the water, for recycling or other purposes. More usually, however, the requirement is for the water emerging from the pipe to be infiltrated directly into the ground. In Fig 1, this is done

through an infiltration station 30.

In Fig 1, the pipe containing the body 23 of foam, comprises a highly efficient aeration station 32. The aeration station 32 promotes the oxidation reactions; i.e if the water from the septic tank has a high organic content, the aeration station supplies the oxygen needed to diminish the carbonaceous-BOD and the total suspended solids (TSS). Oxidation (nitrification) of ammonium can also occur.

There are many conventional structures that can be used at the infiltration station 30. It may be noted that in a conventional septic treatment system, which has a conventional tile-bed soakaway, the tile-bed soakaway comprises not only the infiltration station, but the tile-bed soakaway also doubles as the aerobic treatment station. It is recognised that the function of the conventional tile-bed as an infiltration station is much less demanding (in terms of the size of bed required) than its function as a oxidation treatment station.

In Fig 1, the infiltration station 30 comprises a soakaway, but now the soakaway can be much smaller (and cheaper) than the soakaway would have to be if the soakaway itself served also as the aerobic treatment station. A conventional tile-bed combines the functions of aeration station and infiltration station; since a conventional tile-bed does not always make a very efficient aeration station, the whole installation is large, which is not only expensive but occupies a large area of land. By separating the aeration function and the infiltration function into two separate stations, i.e the aerobic treatment station 32 and the separate infiltration station 30, as in Fig 1, the overall installation can be more economical, and can use the available premium space more efficiently.

Fig 4 is a plan view of a wastewater installation. Un-aerated water from the septic tank enters the system at 34, and a distribution box 35 (of conventional design) distributes the water between the four pipes 20a-20d, as shown. The four pipes as shown are straight and parallel, but that is not essential: sometimes it might be more convenient to arrange the pipes in curves, to follow the contours of the land.

Once the sewage flow rates and dosage requirements that the system will have to cater for have been determined, the designer needs to choose between having one large pipe, or several smaller-diameter pipes. The factors to be considered when making this choice have to do not so much with the aeration station itself, but e.g with the depth of workable soil at the site, and the ability of the ground material at the site to accept the discharge of treated water over a long period of service.

The treatment material as shown in Fig 2 is of open-cell, or connected-cell, plastic foam. Foam is preferred as the microbe-habitation material because foam can be produced in the desired shapes easily and cheaply. Foam can be made flexible and resilient, whereby the foam can be a tight fit in the pipe, which ensures water cannot by-pass the foam, and by-pass the colonies of microbes residing in the foam. Plastic foam material can easily be formed into a cross-sectional shape that just fills the pipe.

Other materials may be used as the microbe-habitation material, if they are absorbent and permeable. For example, peat may be used. Another suitable material is rock-wool. Rock-wool comprises a mat of fine threads or fibres of rock, ceramic material, glass, etc. Rock-wool, like open-cell foam, provides very effective habitations for microbe colonies, while having only a minimal tendency to become clogged with slime and solids. Rock-wool also, like foam, has the capillarity or absorbency to retain the water within the material for a good time period.

It is beneficial for the water to be retained, since that enables an efficient use of the material. As water drains out of the treatment material between dosings, inevitably a certain portion of the volume of the treatment material becomes empty of water between dosings; and the smaller this portion, the more efficient the use of the material, and the more efficient the use of the volume needed to contain the material.

To illustrate this point, attention is directed to Figs 5a,5b,6a,6b. (In Figs 5a,5b,6a,6b, the vertical distances are exaggerated.)

In Figs 5a,5b, a porous treatment material comprises highly-absorbent foam or rock-wool. Fig 5a shows the situation just after a dose has been applied to the left end of the pipe. The material is saturated, right to the top of the material, for a length LS, the rest of the line of the water-table being as illustrated. Then, dosing ceases, i.e. no more water is applied to the left end. Some water drains out of the right end of the pipe, and the water-table gradually sinks. After a time, which might be several minutes, or perhaps half an hour, the water-table has sunk to a stabilisation level, as shown in Fig 5b, at which no more water, or only a small trickle, drains out of the right end (assuming no more doses have been applied in the meantime at the left end).

In Figs 6a,6b, the porous treatment material is a sand, having only a minimal (though not zero) absorbency. Now, immediately after the dose is applied (Fig 6a), the saturated length LS is much shorter. Also, (Fig 6b) the between-dosings water-table stabilises at a much lower level. Furthermore, the time taken for the water to drain out, from the Fig 6a condition to the Fig 6b

condition, is much shorter than the time for the water to drain out from the Fig 5a (absorbent foam material) condition to the Fig 5b condition.

The volume of wastewater that is effectively presented to the microbe colonies for treatment depends on the volume of wastewater that is retained within the treatment material between dosings. The effectiveness of absorbency may be seen by comparing highly-absorbent foam or rock-wool (Figs 5a,5b) with minimally-absorbent sand (Figs 6a,6b). In Figs 6a,6b, the length of the pipe, and the length of the treatment material, would have to be much greater in order for the retained volume of wastewater to be comparable.

Sand can be used in the invention, provided it has some capillary absorbency, and provided the extra length of pipe can be accommodated. It is contemplated that, where the material lacks absorbency, in place of resorting to more material, the water emerging from the exit end of the material can be collected and re-cycled through the treatment material; possibly several times. A sand, or gravel, or other porous material, that basically has no capacity for capillary absorption, is not preferred for use in the invention.

A material is suitable for use in the invention if the material is capable not only of supporting vigorous colonies of microbes, but is capable also of capillary action; that is to say, the material should retain and support a substantial body of water, within the material, after the material has been saturated with incoming water. Thus, the material is such that water moves through the pipe, from end to end, progressively with each dosing of incoming water.

To be suitable for use in the invention, the material has to be porous and permeable. Silt or clay would soon become clogged and plugged with solid products, and should not be used. In fact, when it comes to clay, silt, sand, gravel, etc (termed particulate materials herein), as the material for the invention, it should be understood that the range of properties that will lead to effective treatment is quite narrow; the smaller the particulates, generally, the more absorbent the sand material, but the more likely it is that the material will become clogged with slime and solids. Thus, although particulate materials can sometimes be acceptable, generally, particulate materials are not preferred.

Preferably, the nature and volume of the treatment material, and its arrangement in the pipe, should be such that the volume of wastewater retained in the treatment material between dosings is several times larger than the volume of the individual dosings.

To use rock-wool as the microbe-habitation material, the material may be pre-formed into a body having a cross-sectional shape similar to that shown in Fig 2, or may comprise loose material, placed in a bag, with an air tube (and with a means for ensuring that the air tube is at the top of the pipe).

The shape of the pipe and of the treatment material should correspond, to make sure there are no free conduits the water might take through the pipe, and thereby by-pass the treatment material. The treatment material should be tailored to fit tightly against the (bottom of the) pipe, whether that is round, square, or of another shape.

After the treatment system has been operating for some time, the treatment material can be expected to have become divided into treatment zones. The treatment material in the first few metres of the treatment pipe will be stained and discoloured, which is the usual indication of an effective decrease of the BOD (organic) content. Downstream of that zone, the treatment material is less discoloured, and this less-discoloured zone extends for many metres, indicating a large capacity for treating the ammonium and pathogen pollutants, in the pipe, down to very low concentrations.

It can be expected that a well-designed treatment pipe system will clean the water down to a level of ten mg c-BOD per litre, ten mg TSS per litre, and three mg ammonium per litre.

After a long period, it should be expected that some zones of the treatment material in the pipe might have become clogged with a build-up of slime and solids. The system can cope with such clogging, because, if it happens, doses of incoming water simply flow along the air-passage 24, and by-pass the clogged area; the incoming dose of water passes downstream along the air-passage until it reaches a zone of the treatment material that is not clogged. An incoming dose of water simply overflows along the air-passage until it can soak down into the foam material.

The treatment material cannot be expected to last for ever, and the system may have to be cleaned out. This is a simple enough operation, in that the designer can easily arrange for the blocks of foam to be removable from the pipes, for service, and can usually arrange that the blocks are removable without the pipes having to be dug up or dismantled.

As shown, the pipe 20 is arranged in a horizontal configuration and water passes along the pipe in the manner as described; that is to say, as an incoming dose appears at the entry-end of the pipe, corresponding volumes of water are displaced, in bucket-brigade fashion, along the length

of the pipe, and a corresponding volume of water drops out of the exit-end of the pipe, over a period of time. To promote this manner of movement of water through the treatment pipe, it is not essential that the pipe slope downwards towards the exit end. The pipe might even slope (very slightly) uphill, and a volume of water would still emerge from the exit-end as a dose is applied to the entry-end. (Uphill is not recommended, though, because water might pool in certain areas and become stagnant, or block the air-passage.)

The designer should arrange that the slope of the treatment pipe should be kept to a minimum. The treatment pipe should be horizontal, or slope slightly downhill. It is recognised that the treatment pipe, containing a body of foam or other treatment material, does not need to be installed with a constant accurate horizontality, or a constant accurate slope. So long as the pipe is approximately horizontal, that will do.

Figs 7 and 8 show an alternative manner of infiltrating the treated water into the ground. Here, the treatment pipe 41 is located inside a chamber 40, which is formed from a plastic hood 42. The hood is located in an excavated trench, and covered over with soil etc. The design of the hood and the trench is such that air can enter the air-passage 43. It can be arranged that air enters the chamber through the hood, and through a light covering of soil, if the hood and the soil are suitably permeable. The treatment pipe 41 is supported off the floor 45 of the chamber, either from the floor or from the hood.

Water emerges from the exit-end 46 of the pipe, into the void space of the chamber 40, and travels along the floor 45 of the chamber. The floor may be bare soil, or may have pebbles etc to help spread the infiltration uniformly over the area.

Figs 9 and 10 show another alternative arrangement. Here, a similar chamber 47, with a hood 48, is provided, but now the treatment material 49 is placed on the floor of the chamber, i.e on the ground. The pipe 50 itself contains no treatment material. Incoming doses of water travel along the pipe, and the water drips from holes 52 down onto the treatment material underneath. The water then moves laterally through the treatment material before entering the ground. The drip-rate through the holes 52 and the volume of the pipe 50 should be such that one dose of water fills the pipe; if the pipe were larger than that, or the volume of water per dose were too small, the water in the dose might not reach the far end of the pipe. To ensure that the pipe is filled along its length, it might be preferred for the incoming water to be collected prior to being fed into the pipe, and pumped into the pipe in doses of, say, twenty litres.

In some cases, steps must be taken to ensure that the water passes lengthwise (i.e horizontally) for a considerable distance, through the treatment material. To this end, it may be arranged that a trough 54 be interposed between the treatment material 49 and the soil of the floor of the chamber 47. The trough 54 ensures that water cannot escape downwards and into the ground soil except at gaps or holes 56 in the trough. Care is taken that the gaps 56 do not lie underneath the drip holes 52, but are positioned so that water has to travel horizontally through the treatment material 49.

Basically, in the invention, the volume of treatment material through which the water passes is large, but the volume is configured more as a long channel of narrow cross-sectional area, rather than as a volume having a short-length, wide-area, configuration. The long-narrow configuration of the conduit of treatment material through which the water is constrained to pass, ensures that the incoming doses remain within the treatment material for a long residence time. The long-narrow configuration promotes the desired bucket-brigade mode of transport of the water progressively along and through the treatment material. The long-narrow configuration ensures that, as much as possible, the water cannot by-pass any portion of the volume of the treatment material. Any portion of the volume of treatment material that is not effectively being used to treat wastewater, is wasted. It is an aim of the invention to maximise the portion of the volume of the treatment material that is available for use, and is used, to treat wastewater.

Another major benefit that arises from the treatment material being configured in the long-narrow configuration is that the water to be treated is applied, locally, just to one end of the treatment material. This may be contrasted with conventional systems in which the incoming water has to be forcefully spread out, and spread out reasonably evenly, over a horizontally-large area of treatment material. Consider, for example, the conventional systems where the treatment material is configured basically as a horizontal mat, and the incoming water has to be sprinkled over the whole of the upwards-facing surface of the mat. This requires the provision of a (powered) sprinkler or similar horizontal water-distribution system. In those systems, if the water were to be fed just to a single point above a horizontally-extending mat, the water would not spread evenly over the whole mat, but would simply penetrate down through just the immediate sector of the treatment material.

By contrast, the long-narrow configuration of the treatment material does enable water to be fed into a large body of treatment material from a single inlet point, without the use of sprinklers or distribution systems. In a well-engineered system that embodies the invention, all the water entering the system, upon being simply placed at the left end of the pipe, cannot fail to flow along

the pipe, and cannot fail to pass through metre after metre of well-aerated microbe-laden treatment material.

It is not ruled out in the invention that a pump might be needed for moving water to the inlet point. However, a conventional system that uses a sprinkler to spray water outwards and downwards onto the treatment material is much more likely to need a pump than a system that simply places the water alongside the treatment material.

It is not essential, in the invention, that the treatment material must provide capillary action. The treatment material must be such that the material will support colonies of microbes, and should be such that the material will not easily become clogged with slime. Also, the configuration of the treatment material, and of the constraints that determine the pathways the water takes in passing through the treatment material, should be such that the doses of water pass through in bucket-brigade mode.

These criteria can be met with an alternative form of material, as shown in Fig 11.

In Fig 11, a round pipe 57 contains inner and outer pieces 58,59 of bristle-mat. The mat comprises artificial turf, such as AstroTurf (trade name). The two mats of artificial turf are rolled into spirals, one left-handed, the other right. The arrangement leaves an outer gap, which serves as an air-passage 60, running along the length of the pipe 57. The arrangement also leaves another air-passage 62, running the length of the pipe, being the central tubular passageway as shown. The mat should be so selected for size, and be so arranged, that the bristles or blades of the artificial turf are compressed slightly, whereby the mat fits tightly against the walls of the pipe.

Water dosed into the pipe 57 enters between the turns of the mat, and flows along lengthwise between the turns. The artificial turf material provides an excellent habitat for microbes, and the arrangement means that there is ample provision for circulation of air, and for oxygen access for microbes residing on the bristles or blades of the turf mat.

Artificial turf does not promote a capillary action, and therefore if the pipe 57 as shown in Fig 11 were to be inclined downhill, it might happen that too much of the water being treated would drain out of the pipe, and out of the treatment material, between dosings. The Fig 11 pipe therefore should be arranged so that water does not drain completely, between dosings, which can be done by placing the water outlet (slightly) higher than the bottom of the pipe. Now, the water remains in the turns of the rolled mats, between dosings, and the long-narrow character of the

water-ways between the turns promotes the desired bucket-brigade mode of movement of water along the pipe, as each new volume of water is dosed in. The water should occupy less than half the cross-sectional area of the pipe: the line 63 indicates an optimum residual water level.

If an area of the blades or bristles should become clogged with solids and slime, water could flow up and around the curved paths between the turns, and over the obstacle. There is generally no need for the mat to be perforated (to give direct communication between turns) and too many perforations might lead to too many possible pathways through the treatment material, and to the water starting to find preferred pathways. On the other hand, if desired, the mat may be perforated.

As mentioned, it is a preferred feature of the invention that the water be constrained to flow through a volume of treatment material that is configured as a long-narrow volume. The more the material is disposed, with respect to the passing water, in a long-narrow configuration, the less likely it is that preferred pathways might develop in the material, whereby water might by-pass some of the material.

The manner in which the long-narrow character of the treatment material is defined, in the context of the invention, will now be discussed.

The water may be regarded as flowing through or along a water-conduit, in which the treatment material is contained. The water-conduit has a floor, which is contiguous with left and right side-walls.

If the water-conduit had a simple rectangular cross-section, the floor and side-walls of the water conduit would be immediately defined. When the water-conduit is some other shape — a round pipe, for example — just what constitutes the floor of the water-conduit is not so immediately clear. In the context of the invention, the floor of the water-conduit is preferably defined as including not only the bottom of the conduit but also those portions of the conduit walls that face upwards, and lie at no more than thirty degrees to the horizontal. Any portion of the water-conduit walls that lies more steeply to the horizontal than thirty degrees should be regarded as a portion of the side-wall of the water-conduit, not as a portion of the floor.

The treatment material rests on, and makes contact with, the floor of the water-conduit. The treatment material also makes contact with at least a lower portion of the side-walls of the water-

conduit. The floor of the water-conduit includes contact-patches, where the treatment material actually touches the floor, and non-contact-areas, between the contact-patches, where the treatment material does not touch the floor. If the treatment material is in touching contact with the whole of the floor surface, the non-contact-areas in that case would be zero, and that is to be desired, but zero is not essential.

The water, in passing from the entry-port to the exit-port, takes flow-paths through the treatment material. The flow-paths are traced on the floor of the water-conduit, by water passing from the entry-port to the exit-port, and the flow-paths incorporate the non-contact-areas of the floor, if such be present.

The clearest-flow-path is the flow-path that brings the water into the least contact with the treatment material. It is a preferred feature of the invention that even the clearest-flow-path lies within two millimetres of the treatment material over a distance of at least ten metres.

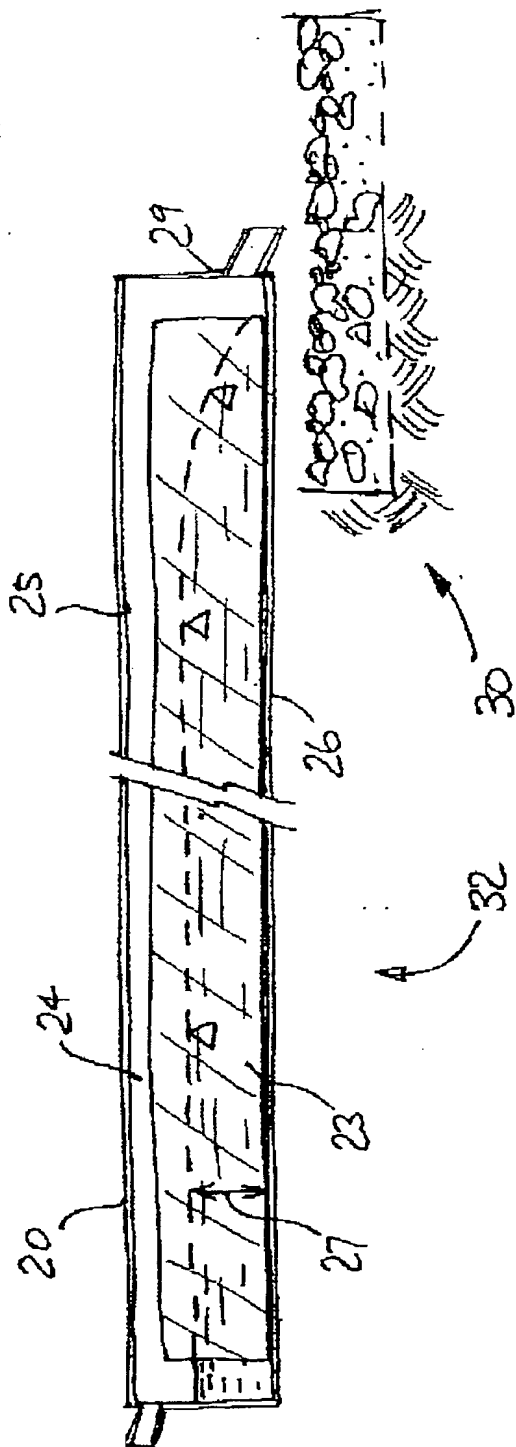
In the invention, it is preferred that the width of the water-conduit be narrow, defined as follows. The width of the floor of the conduit, as measured laterally with respect to the length of the water-conduit, is  $W_1$  metres at a point  $T_1$ , is  $W_2$  metres at a point  $T_2$ , and is  $W_N$  metres at a point  $T_N$ .  $T_1, T_2, \dots, T_N, \dots$  are points along the length of the water-conduit at which the treatment material is present. It is preferred, in the invention, that at least eighty percent of the widths  $W_1, W_2, \dots, W_N, \dots$  are less than forty centimetres. The aggregate of all the flow-paths through the treatment material is the stream-path.

The designer should take precautions against freezing, if appropriate. The pipe should be free-draining, and typically buried with about fifteen cm of soil above the pipe, to accommodate minus 20 degC. More soil or insulation should be provided over the pipe in colder climates.

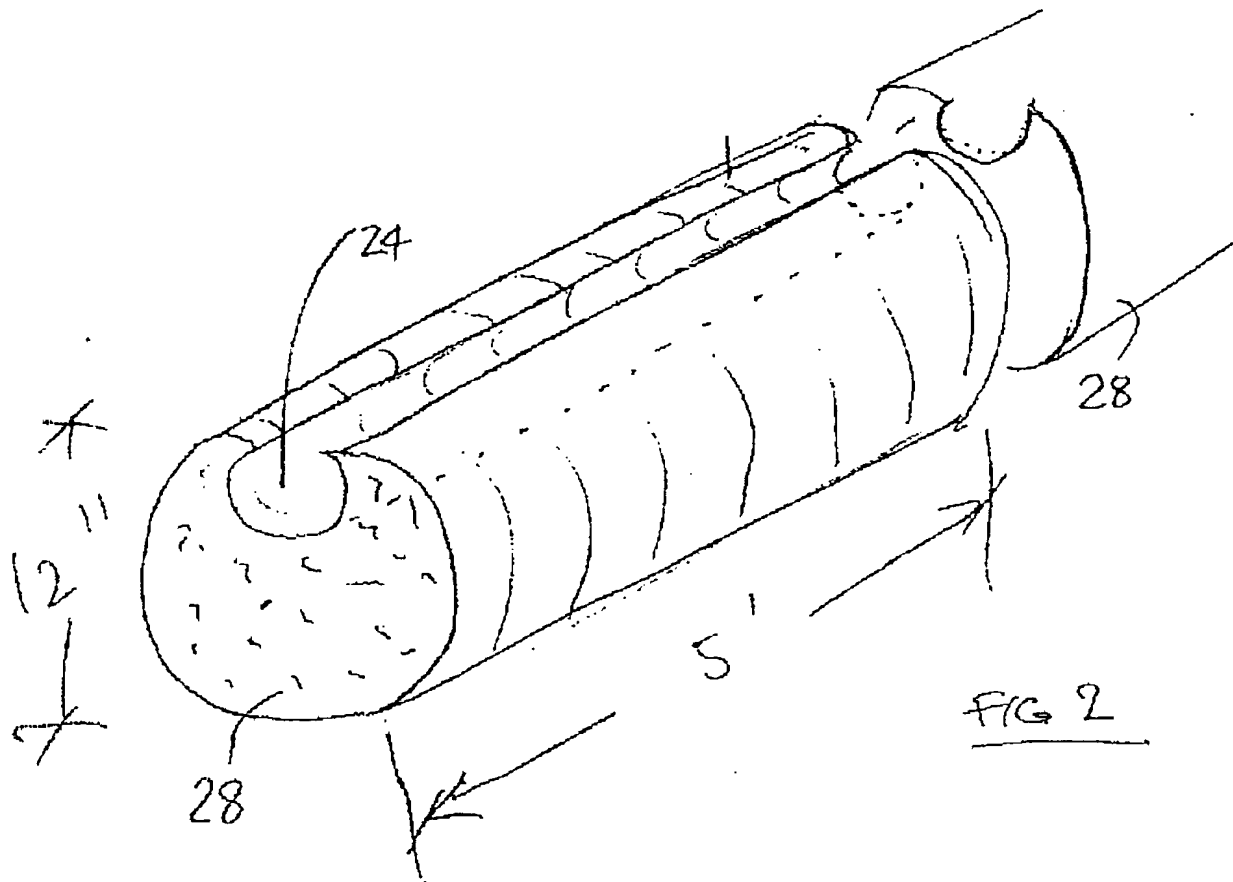
Anthony Asquith  
Agent for the Applicant  
Docket: 268-55GB-Prov



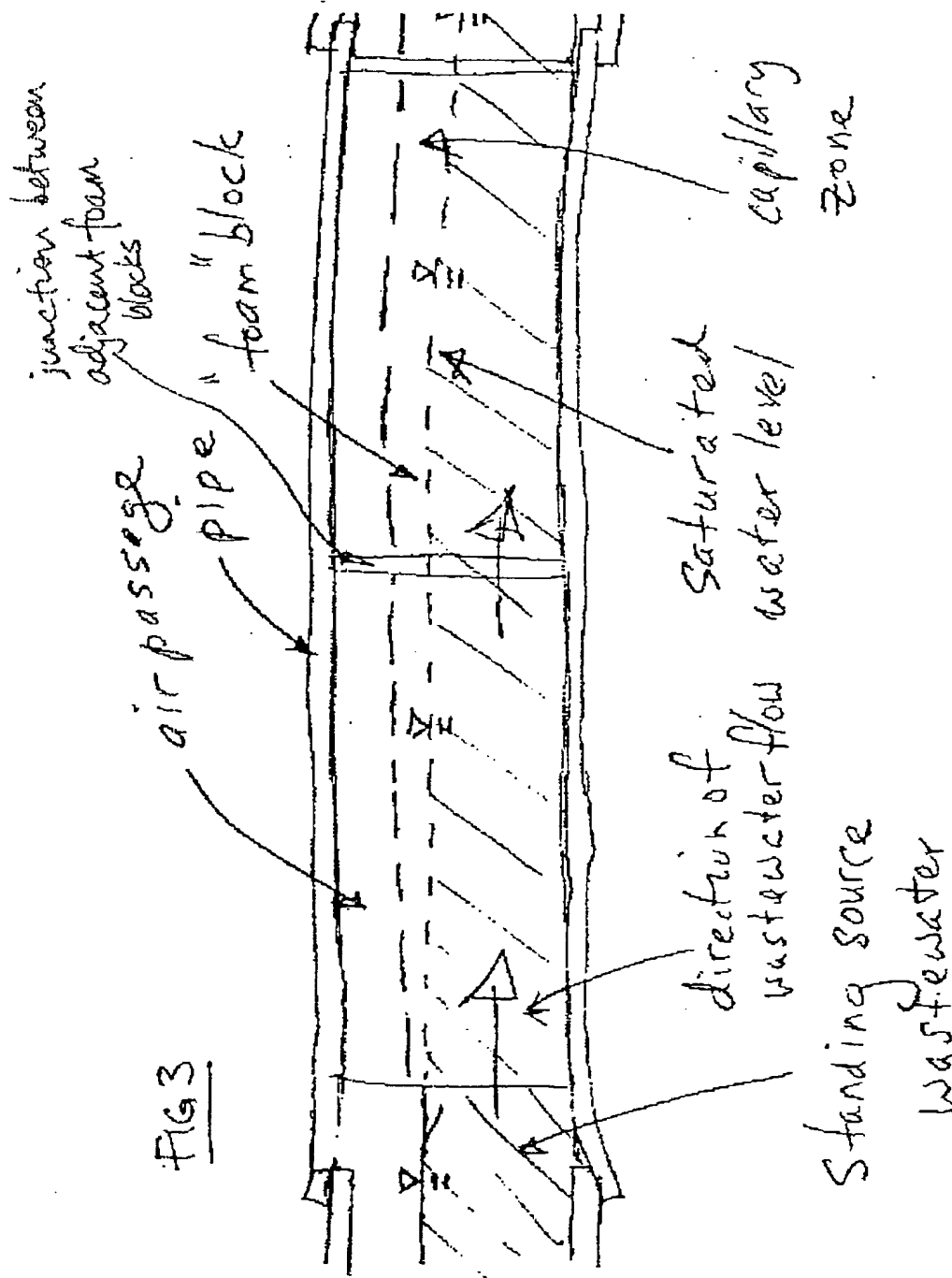
FIG 1













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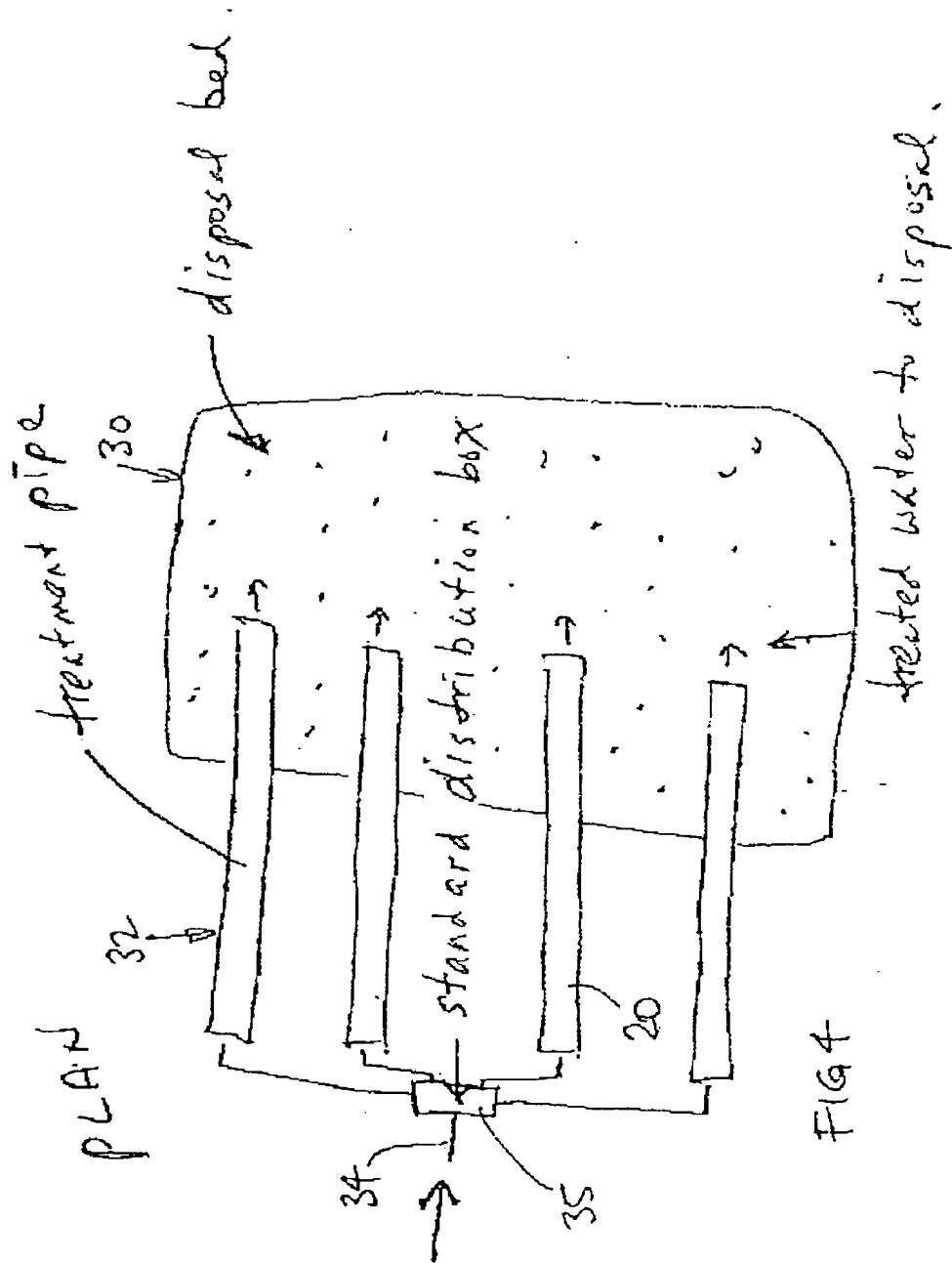




FIG 5a

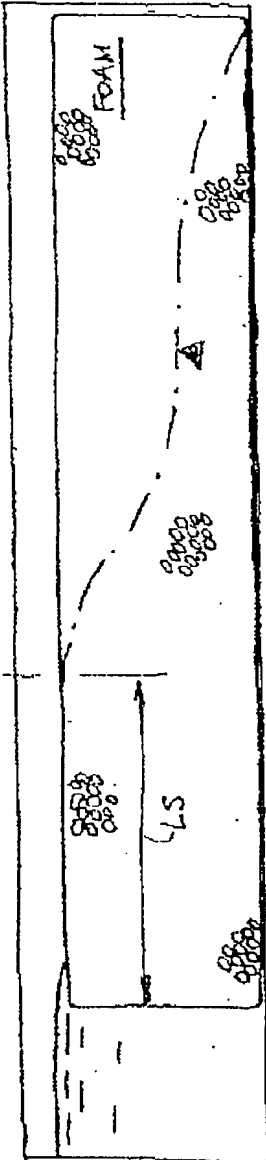


FIG 5b

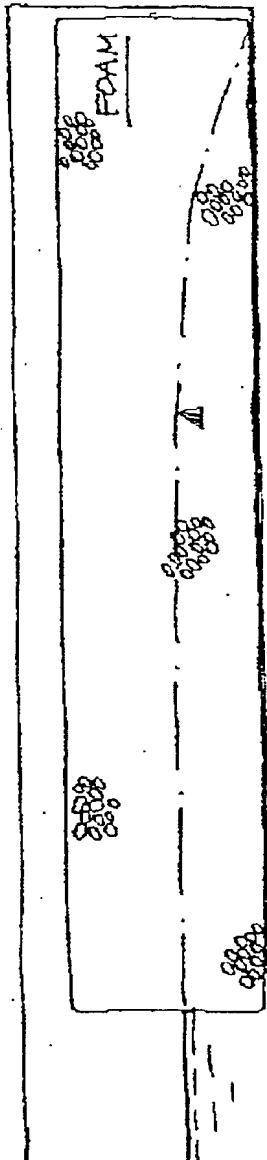


FIG 6a

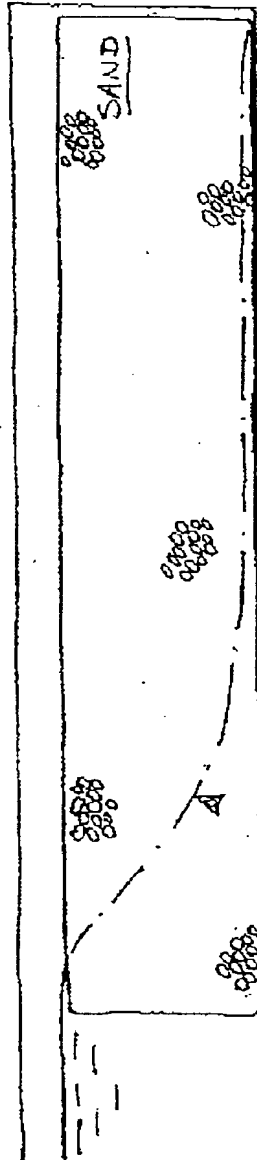


FIG 6b

